Application of Link 16 Technology To Future Air Traffic Control

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Introduction

Three areas of discussion:

- Future ATC Goals
- Data Link Approach
- Candidate Architecture

Overview

- **Where is the Beef? Or bandwidth that is !!!**
- **Who am I talking to on the other end of this thing?????**

The Problem

- **VHF Radio's will not have adequate bandwidth to carry all of the necessary data required for Free Flight**
  - VHF Band is Congested
  - Channel centers are basically a narrowband design
  - Security of waveform may become a significant issue

A Shift in Philosophy

- **Current Approach**
  - **FAA (through ATC) is responsible for:**
    - Air traffic direction: Clearances, vectors, etc.
    - Air traffic separation and situational awareness
  - **Pilots are responsible for:**
    - Following ATC instructions
    - Air traffic separation and situational awareness in VFR conditions and using TCAS
- **Future Paradigm**
  - **FAA responsible for air traffic direction**
    - Computer assisted traffic flow
    - Computer assisted air traffic separation
  - **Pilots responsible for situational awareness in IFR and VFR conditions**
    - Air traffic collision avoidance
    - Weather

Link 16 Evolution

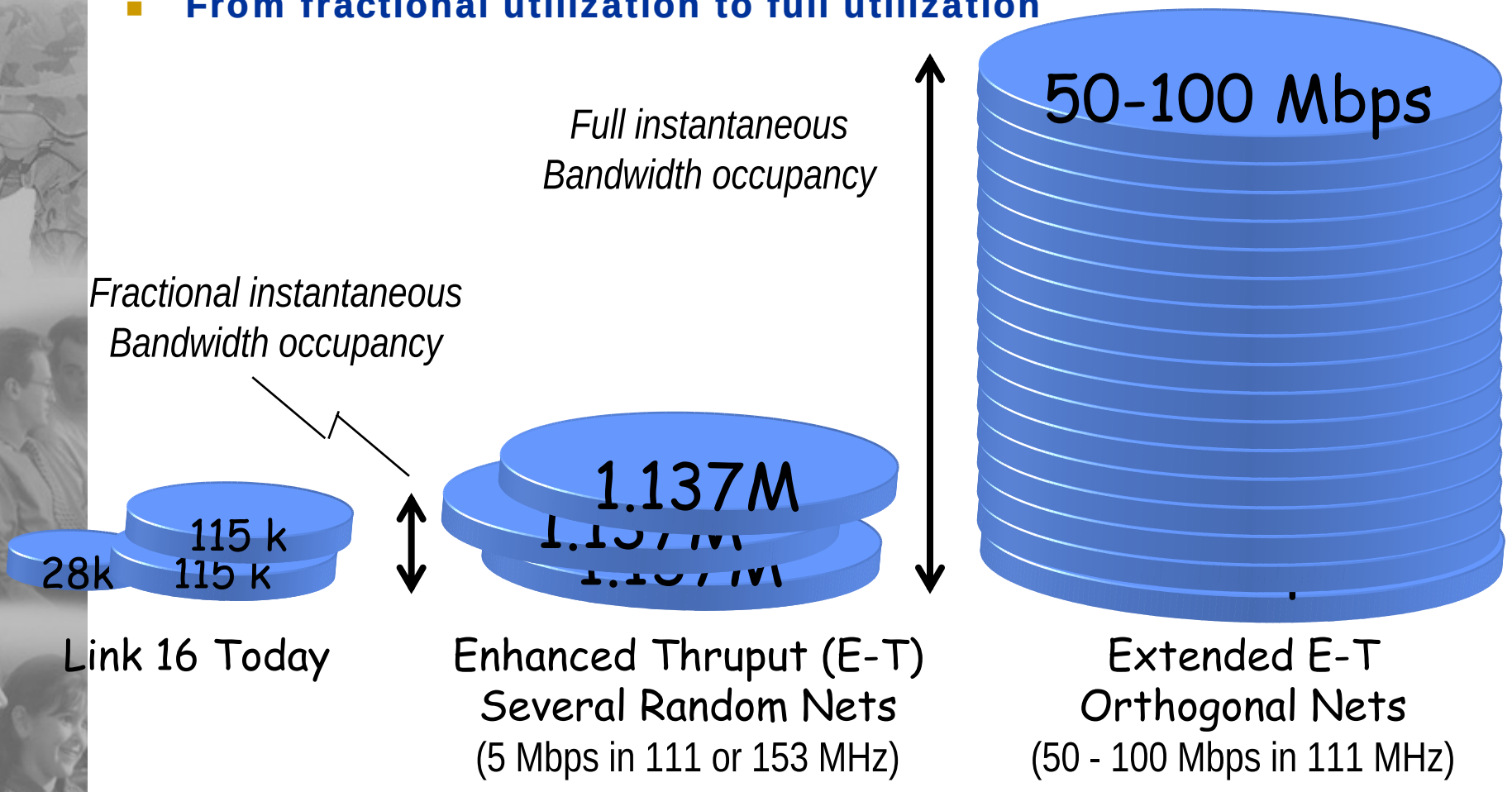
Fixed S/A & C2 Messages	Open IP Network + S/A & C2
28 – 115 kbps in single nets	50 – 100 Mbps in multiple nets
4 AJ levels	Real time QoS – AJ Trades
MIDS Specific design	JTRS SCA Compliance
CDH Transec/Comsec	Programmable INE
Pre-planned net entry/exit	Dynamic ad-hoc networks
Static network relay	Dynamic message routing

While Preserving:

- ✓ **NTIA / FAA emissions compliance**
- ✓ **Coalition interoperability**
- ✓ **MIDS LRU replaceable**
- ✓ **MIDS platform installation schedules**

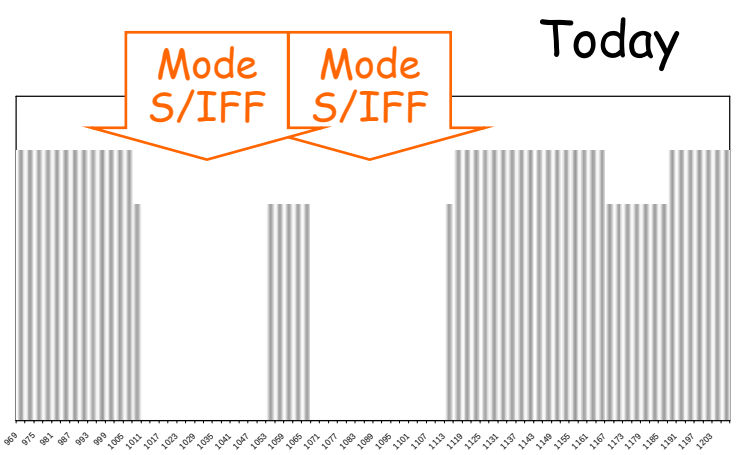
Bandwidth Utilization

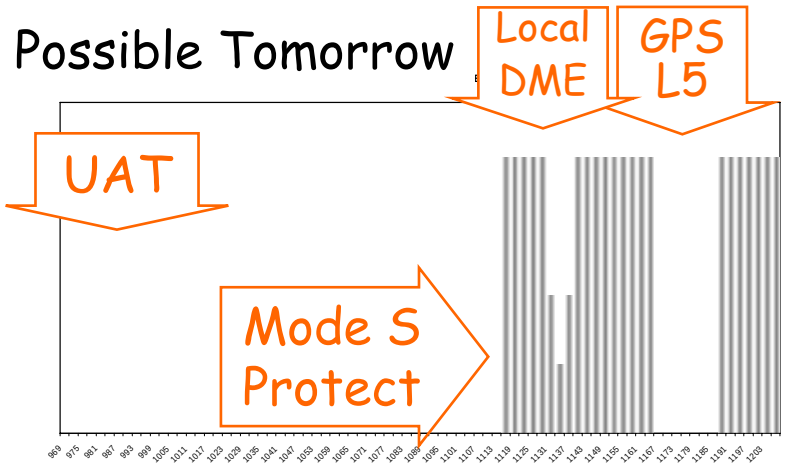
- **From fractional utilization to full utilization**



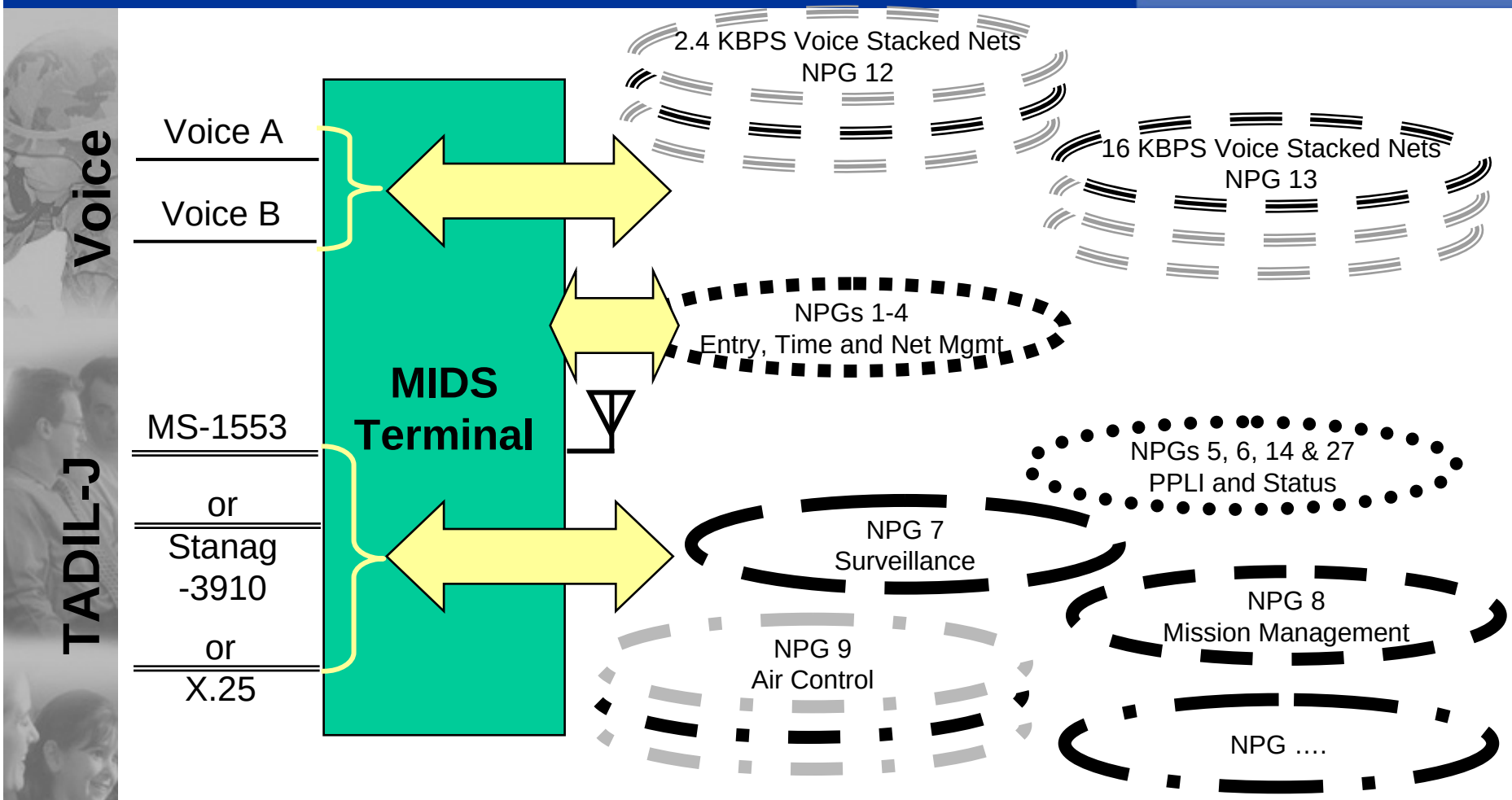
Physical Layer Transition

- **Orthogonal Frequency Hop improves Efficiency vs. Random FH-PN-TDMA**
- **Full Instantaneous Bandwidth Occupancy**
  - With discontiguous frequency allocations
  - Adaptive Coding enables “run-time” trade-offs of throughput, LPI, AJ QoS …
  - Random access mode supports rapid network entry, transient subscribers
    - Allocate % of capacity to non-orthogonal accesses
- **Implement new Waveform in SCA Compliant Radio**
- **"Non-Interference" validation likely biggest hurdle (must ADAPT)**
  - Fundamentally new waveform may invalidate interference “assumptions" of MOAs



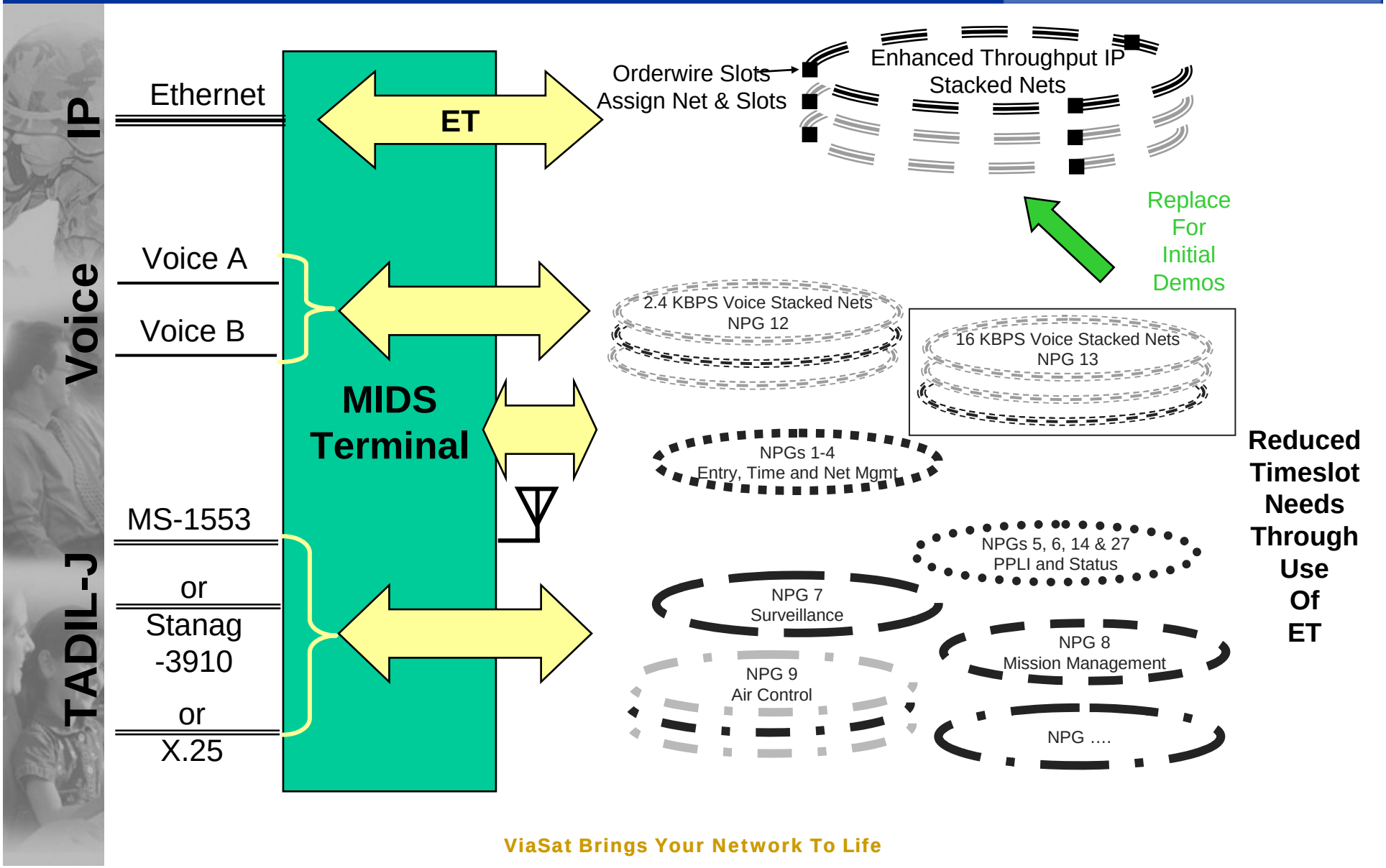


Concept of Link-16 MIDS Today

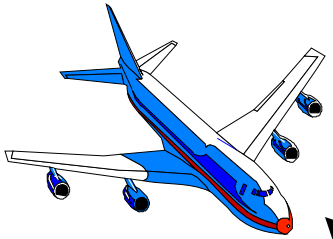


TDMA "Channels" of Operational Need

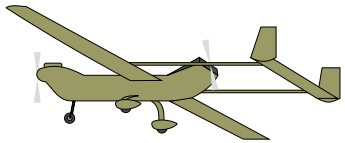
Concept of Link-16 MIDS With ET IP/BoD



The Basic Concept (Combination of Mil and Civil)



Aircraft

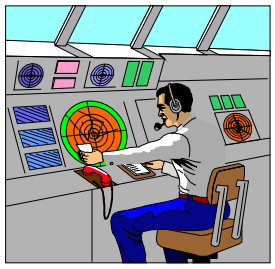


Satellites

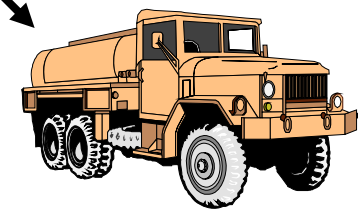
Time Division Multiple Access
Link 16 Type System

Airport
ATC

Enroute
ATC



UAV Mission
Control



Airport Ground
Support Vehicles

Overview of Basic Capability

- **Utilizes all sensor information available**
  - Ground based RADAR (position)
  - Aircraft GPS/INS data (position)
  - VOR/DME data (position)
  - On-board aircraft sensors (airspeed, altitude, heading, velocity, climb rate)
  - Mode C data (altitude)
  - Computed data (ground computers)
  - Weather and NOTAM data for enroute and all terminal destinations
  - Aircraft status (ground, taxi, takeoff, airborne, landing)
  - IFF status (normal, emergency, NORDO, hijacked)
- **Each user transmits appropriate data onto the net**
- **Each user receives appropriately filtered (user defined by range) data for on-board display**
- **Each user receives and retransmits full message for full net coverage**
- **Multi-channel approach allows for terminal and enroute regional separation of messages**

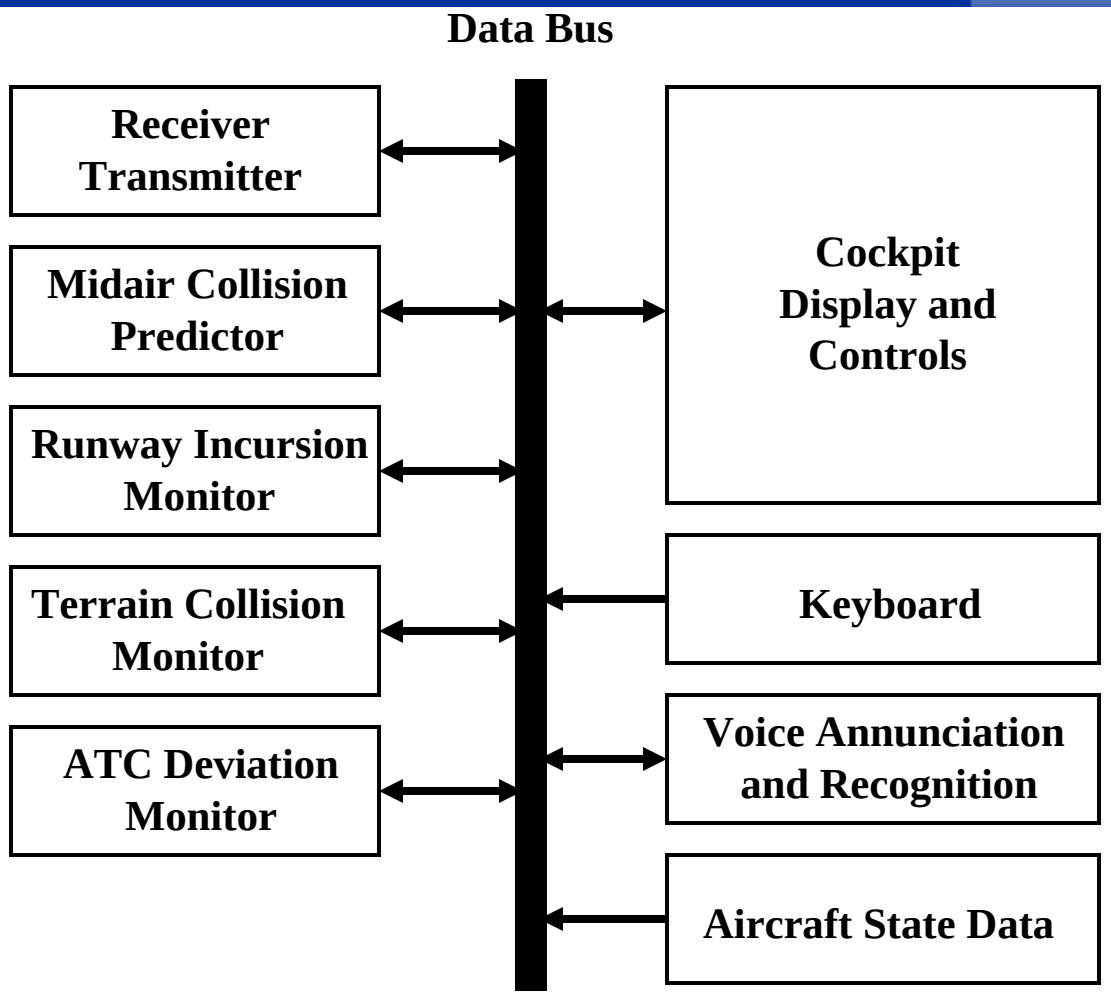
Overview of Basic System

- **Based on U. S. Military JTIDS/Link 16/MIDS**
  - Declassified terminals
  - Military features, such as secure voice and frequency agility, not used
- **Encryption used to avoid hacking**
- **Message formats**
  - Alpha-numeric with voice recognition and audio cues
    - Enroute and terminal messages and vectoring
  - Standard formats for position and status data for all participating aircraft/ground stations
    - RADAR type displays for situational awareness
  - Picture formats for weather data

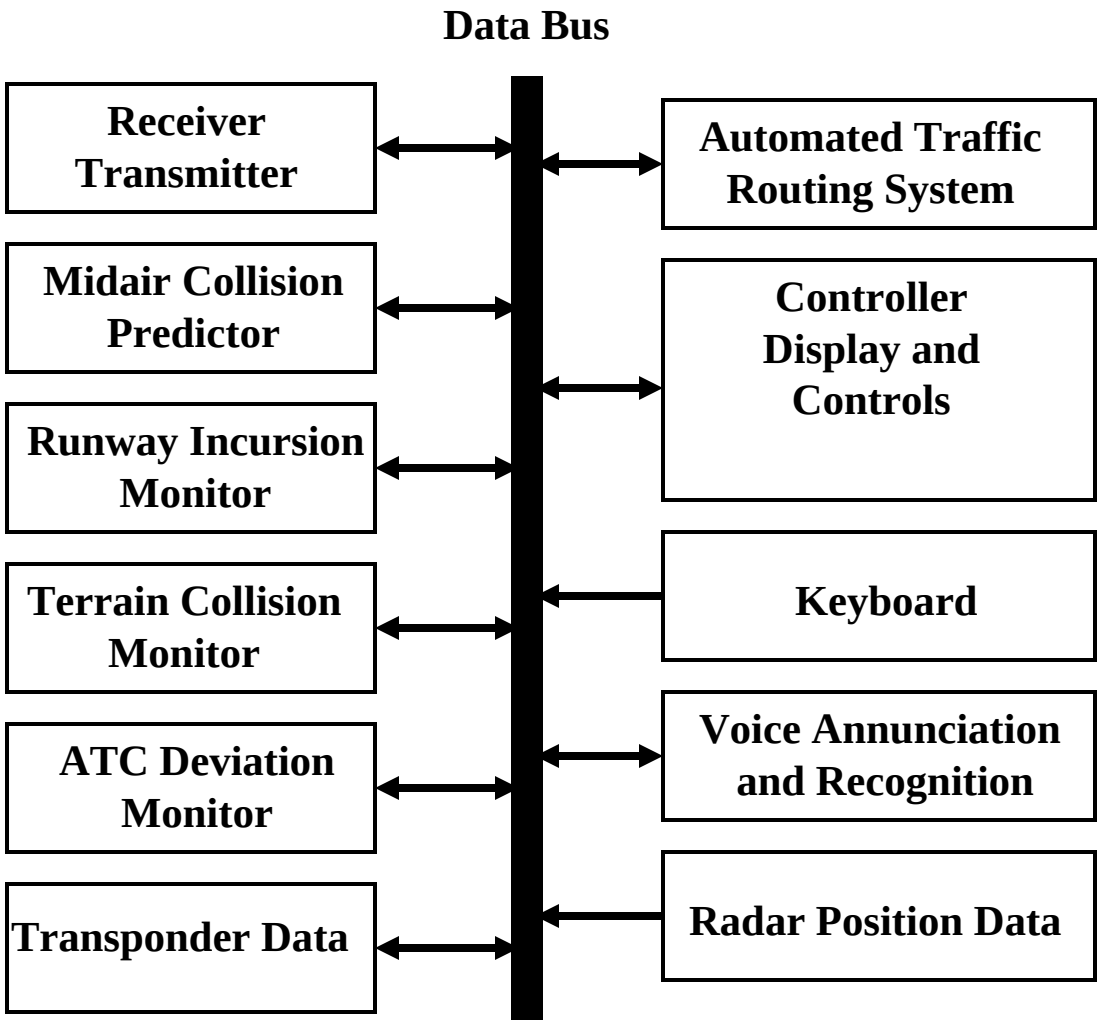
System Enhancements

- **Collision avoidance with other aircraft**
- **Terrain impact avoidance with terrain database at terminal sites**
- **Runway incursion warnings for controllers and all participating aircraft and ground vehicles**
  - Aircraft and vehicle positions plotted on airfield map
  - Map displayed in aircraft, ground control, and ground vehicles
- **Automated air traffic control software development**
- **ATC clearance deviation monitor**

System Architecture - Aircraft



System Architecture - ATC



LINK-16 Architecture

- TDMA
- Nodeless
- Message Encryption (hacker proof)
- Line of Sight (extended via Relay)
- Fixed and Variable Format

Functional Approach: What is an Software Defined Radio

- **Multi-Mode**
  - Multiple Modes of a Single Radio Type in a Single LRU
- **Multi-Function**
  - More than one Communication Function in LRU (Enclosure)
  - Communication, Navigation and/or Surveillance Functions in a single LRU
- **A Software Defined Radio simulates (and communicates) multiple waveforms that provide interoperability with fielded qualified radio's**

Utilize Common Hardware and Software Architecture for future enhancements

MMDA Candidate Architecture